CLIMATE CHANGE IMPACTS ON ECOSYSTEMS: THE RHODES GYRE CASE

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Abstract

The 15 years (1986-2001) hydrographic (temperature, salinity, density), hydrochemical (nutrients, dissolved oxygen) and biological (chlorophyll-a as phytoplankton biomass, primary production) data collected during Turkish and Greek cruises in the Rhodes cyclonic gyre region, northern Levantine are presented. These two data sets were combined and interpreted together and the aim was to understand the interactions between meso-scale physical dynamics and ecosystem processes, and impacts of observed climate changes.

Keywords : Eastern Mediterranean, Upwelling, Primary Production.

The findings obtained during the last two decades have shown that, although the Mediterranean is oligotrophic, locally and temporarily very high planktonic biomasses can be found at some locations. In the cyclonic regions in the Northern Levantine basin, e.g. the Rhodes gyre, where the nutricline ascends to the base of the euphotic zone, phytoplankton biomass and primary production are higher than those in the anticyclonic regions, where the nutricline is situated at greater depths, thereby limiting the nutrient input to the surface waters during winter mixing [1, 2, 3]. Other reasons for the relatively high productivity in such regions are intensive convective mixing during severe winters leading to vertical homogenisation, and upwelling of waters from intermediate and deep layers to the euphotic zone. Re-evaluation and processing of the long-term (1986-2001) Turkish and Greek nutrient and phytoplankton biomass (as chlorophyll-a) and primary production data in the Rhodes Gyre and its peripherals confirmed these findings.

The major nutrient source for the biologically active euphotic zone of the open sea is the input from the nutricline. New production in the open waters of the eastern Mediterranean is therefore dominated by the input from the nutricline through vertical mixing, contribution from riverine input via surface circulations and atmospheric transport being of secondary importance [3]. The permanent nutricline is located between specific density surfaces (29.00-29.05 and 29.15) throughout the eastern Mediterranean basin even though it appears at different depths (at shallower depths in the cyclonic gyres and far below the euphotic zone in the anticyclonic regions) with region and season. The eastern Mediterranean waters are very clear and ultra-oligotrophic with $PO_4<0.02\ \mu M$ and $NO_3<0.3\ \mu M$ in the upper mixed layer in summer and chlorophyll-a is below $0.5\ \mu g\ L^{-1}$ [1, 3]. In this sea, primary production is as low as 45 mgC $m^{-2}d^{-1}$, and bacterial production corresponds to about half of algal production.

The homogeneous water column formation in the Rhodes cyclonic gyre due to strong overturning during 1992, 1993 and 1995 winters resulted in uniform profiles of nutrients down to at least 1000 m. The surface nutrient concentrations reached those of deep water concentrations, *e.g.* $0.16\pm0.02\ \mu M$, $4.7\pm0.4\ \mu M$, $7.8\pm0.4\ \mu M$ for phosphate, nitrate and reactive silicate respectively (Figures 1 and 2). The relevant changes in the molar ratios of nitrate to phosphate, silicate to nitrate and silicate to phosphate in the surface layer between the pre-, post and chimney formation periods reveals that the area is phosphorus limited. NO_3/PO_4 molar ratio was as low as 5-10 at the surface layer for pre- and post-chimney formation periods while it was relatively higher (26-29) at the surface layer and constant in the whole water column down to 1000 m at chimney formation period. The efficient nutrient pumping from aphotic to euphotic zone in the Rhodes Gyre center and its peripherals caused unusually high biomass accumulation and an increase in primary production rates. The highest chlorophyll-a concentration was measured as 3 mg/$m^3$and the primary production rate was as high as 1.1 g C/m^2/d, which were very similar to those observed in the productive Black Sea waters. Such events observed in the Rhodes cyclonic gyre represents good and unique examples of climate change impacts on the dynamical processes and consequent changes in the marine ecosystems.

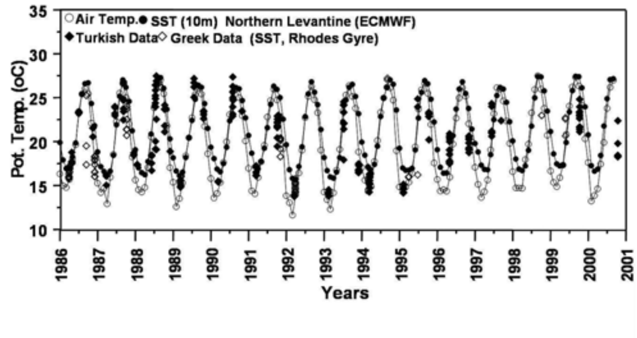

Fig. 1. Long-term variation of Air Temperature and Sea Surface Temperature (SST,°C) in the Northern Levantine. ERA-15 re-analysis monthly averages satellite data set produced by the European Center for Medium-Range Weather Forecasts (ECMWF) are presented.

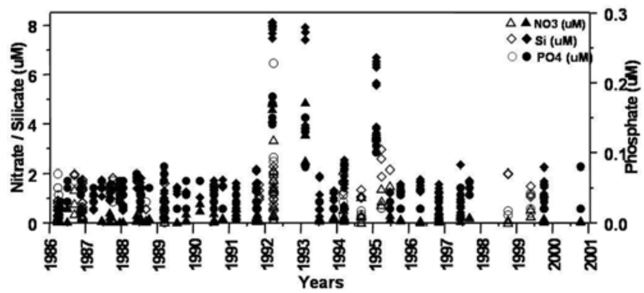

Fig. 2. Surface (the top 20m) nutrient concentrations in the center of Rhodes Gyre. Turkish data are presented by filled symbols and Greek data are presented by open symbols.

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